The Global Burden of Disease Attributable To Air Pollution:

Latest Results and Future Directions for Source-Specific Burdens

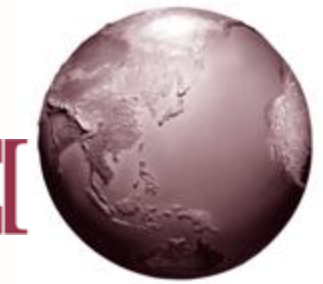
Dan Greenbaum

President, Health Effects Institute

ECT - 2016

New Delhi

9th November 2016



Trusted Science • Cleaner Air • Better Health

Air Pollution and the Global Burden of Disease

- Air Quality and Health
  - Estimating the Global Burden of Disease GBD
    - Health Effects in India and Globally
    - GBD 2015: The Latest Results!
  - Looking Ahead:
    - GBD MAPS: Understanding Source-Specific Health Impacts in China, India and Eastern Europe
  - The Special Case of Traffic
- Concluding Thoughts

The Health Effects Institute

Trusted Science ➡ Cleaner Air ➡ Better Health

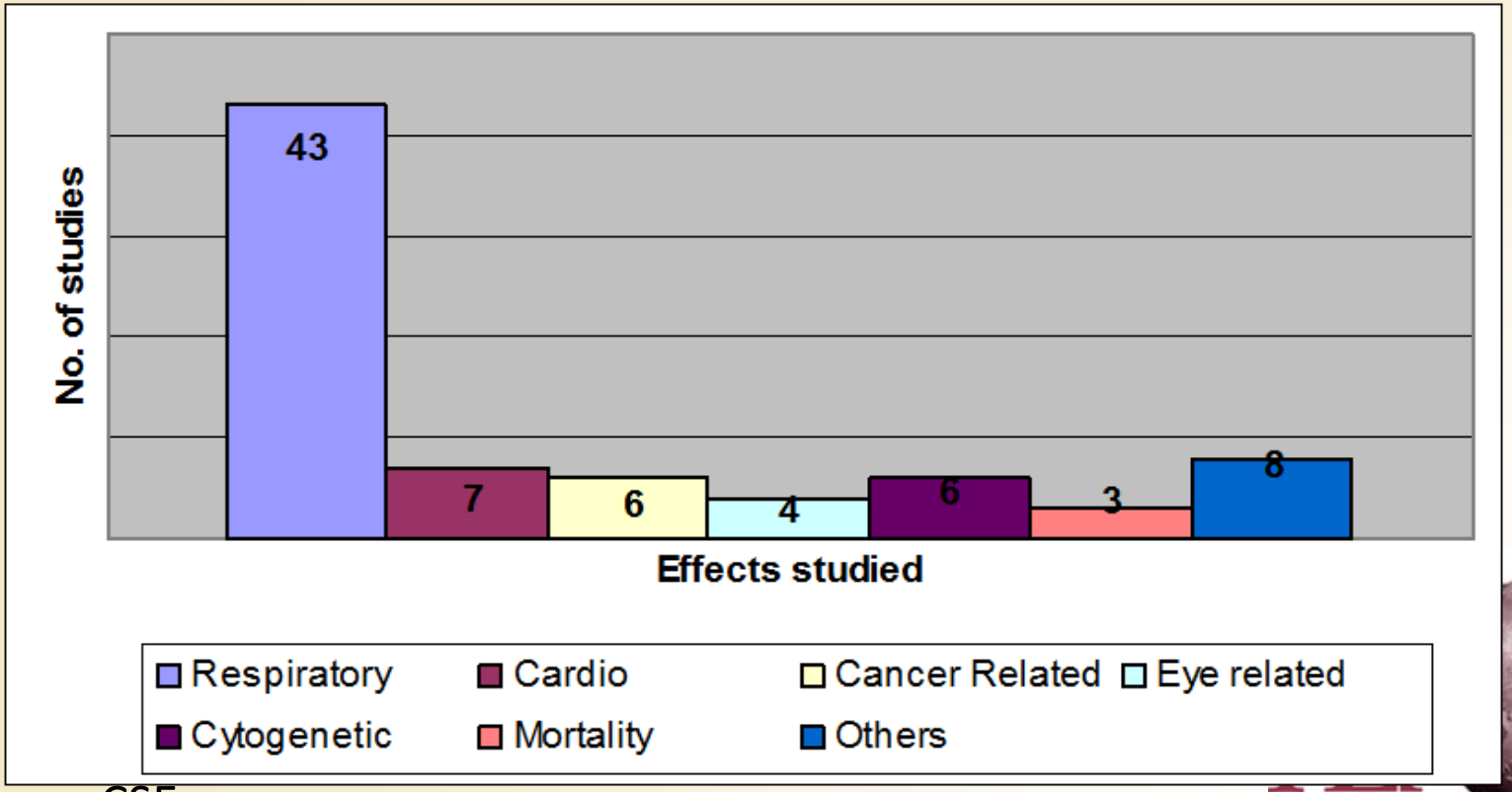
- An independent non-profit institute providing trusted science on the health effects of air pollution for 35 years
- Balanced Core Support
  - US EPA and Industry (Worldwide Motor Vehicle)
- Additional Support and Partnerships
  - Also WHO, ADB, Clean Air Asia, TERI, Sri Ramachandra Medical School, EU, US DOE, industries, foundations, others
- Independent Board and Expert Science Committees
  - Oversee and intensively peer review all science
  - International experts from India, China, many others
- Over 350 scientific studies, reviews, and reanalysis conducted around the world, including increasingly in Asia

Understanding local impacts in a global context to inform policy

HEI

Growing number of Indian air pollution and health studies...

- *Respiratory health symptoms dominate….*
- *Broadening to include cardiovascular, eye disorders, cellular changes, cancer, premature deaths….*



Source: CSE

Also a Growing Number of Ambient Air Pollution Adult Mortality Studies

Find Links between Long term PM and Premature Mortality

(including studies from Asia, Europe, North America)

Study	$PM_{2.5}$ Mean ($\mu g/m^3$)	$PM_{2.5}$ Min ($\mu g/m^3$)	$PM_{2.5}$ $5^{th}/95^{th}$ ($\mu g/m^3$)	IHD HR /10 $\mu g/m^3$ (95% CI)	CEV HR /10 $\mu g/m^3$ (95% CI)	COPD HR /10 $\mu g/m^3$ (95% CI)	LC HR /10 $\mu g/m^3$ (95% CI)
American Cancer Society[a] (ACS)	14.2 N=486133	5.8	8.8/20.0	1.26 (1.16-1.38) n=29875	1.12 (1.01-1.24) n=9116	1.05 (0.95-1.17) n=9006	1.14 (1.06-1.23) 9,557
Six City[b] (SCS)	17.8 N=8096	8.7	10.2/23.6	1.33 (1.16-1.52) n=1065	0.89 (0.67-1.18) n=317	1.17 (0.85-1.62) n=247	1.37 (1.07-1.75) n=351
California Teachers[c] (CTS)	15.6 N=73,498	3.1	8.3/23.0	1.20 (1.02-1.41) n=773	1.16 (0.92-1.46) N=382	1.21 (0.88-1.68) N=196	0.95 (0.70-1.28) n=234
Adventist Study of Health and Smog[d] (ASHSmog)	29.0 N=3,239	12.9	15.0/45.1	1.00 (0.87-1.15) n=145			
Dutch Study of Diet and Cancer[e] (DSDC)	28.3 N=120,852	23.0	24.8/31.8	0.96 (0.75-1.22) n=3,521	1.62 (1.07-2.44) n=1,175		1.06 (0.82-1.38) n=1,670
Male Health Professionals[f] (MHP)	17.9 N=17,545	5.8	12.3/23.4	0.98 (0.71-1.36) n=746			
Nurses Health[g] (NHS)	13.9 N=66,250	5.8	10.0/17.8	2.02 (1.07-3.78) n=379			
Women's Health Initiative[h] (WHI)	13.5 N=65,893	3.4	7.4/19.6	2.21 (1.17-4.16) n=80	1.83 (1.11-3.00) n=122		
Canadian Census Health & Environment Cohort[i] (CanCHEC)	8.7 N= 2,145,400	2.1	3.6/13.8	1.30 (1.18-1.43) n=43400	1.04 (0.93-1.16) n=13300		
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Japanese Cohort[m] (JAPAN)	Mean Not Reported N= 63520	16.8	16.8/41.9			0.89 (0.70-1.12) n=64	1.24 (1.12-1.37) n=518
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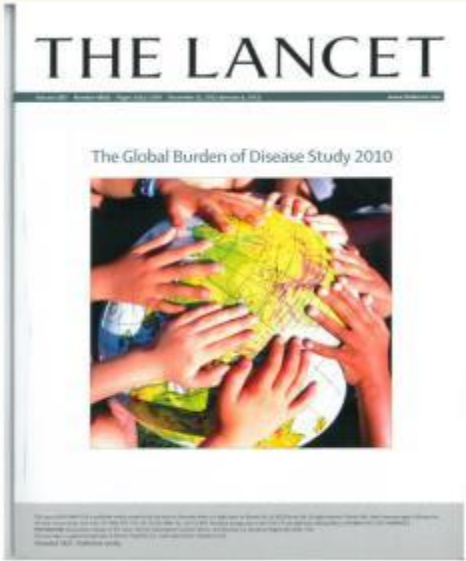
The Global Burden of Disease (GBD)

- A systematic scientific effort to quantify the magnitude of health loss from disease and injuries in 195 countries around the world from 1990 to 2015
  - E.g. cardiovascular disease, respiratory disease, HIV-AIDS, cancer, road traffic injuries, others
- Risks factors associated with those diseases
  - E.g. smoking, diet, high blood pressure, air pollution, overweight
  - GBD 2015, published in *The Lancet* October 2016
- Organized by the Institute for Health Metrics and Evaluation (IHME), U Washington
- ***HEI leadership for outdoor air pollution***

"The latest estimates and analyses from the Global Burden of Disease Study 2015 (GBD 2015) provide a vital link..."

- Dr. Srinath Reddy, PHFI, Lancet October 2016

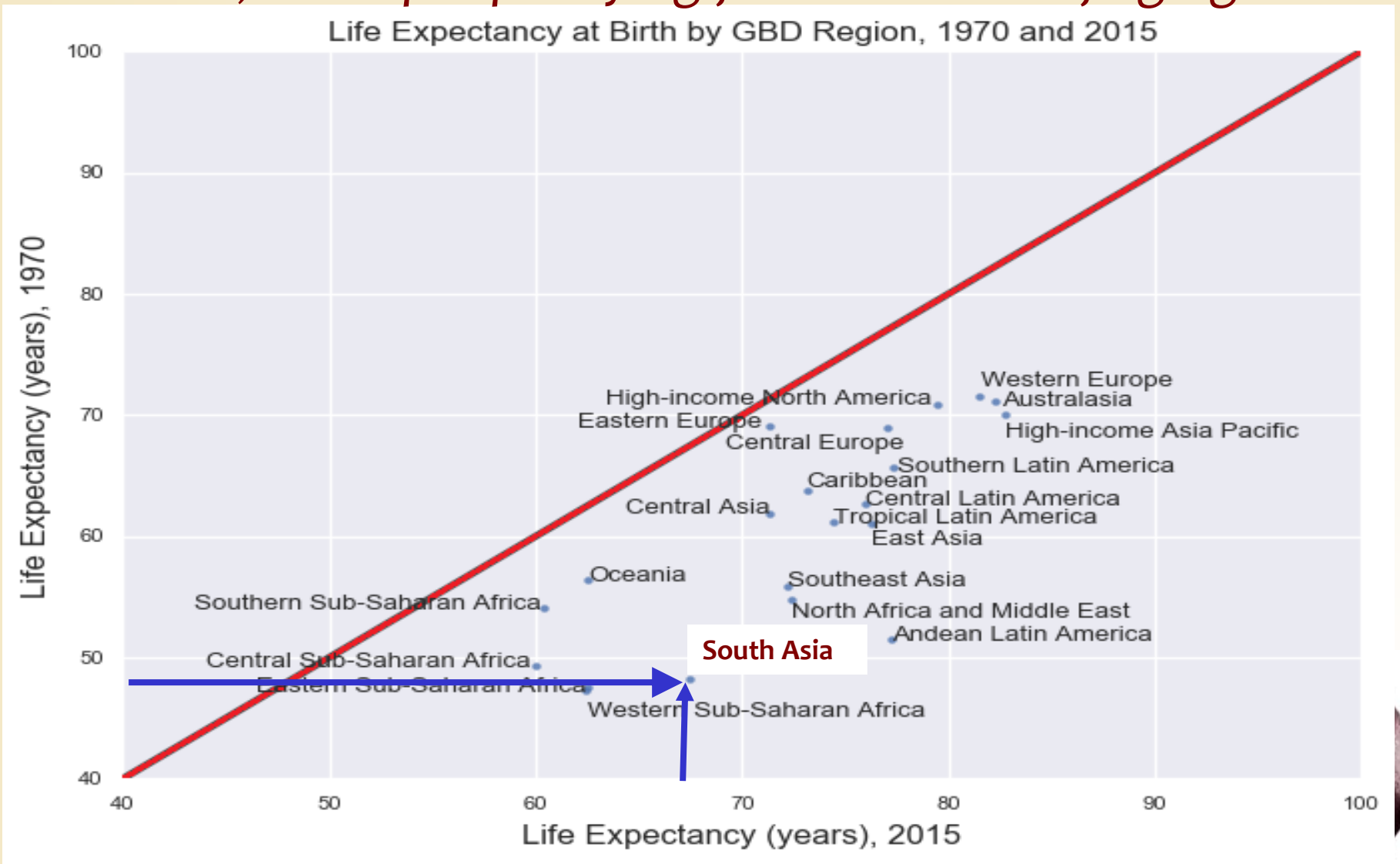


A global study with a global network of investigators: 1,656 investigators, 119 countries

Changes in Life-Expectancy at Birth 1970-2015

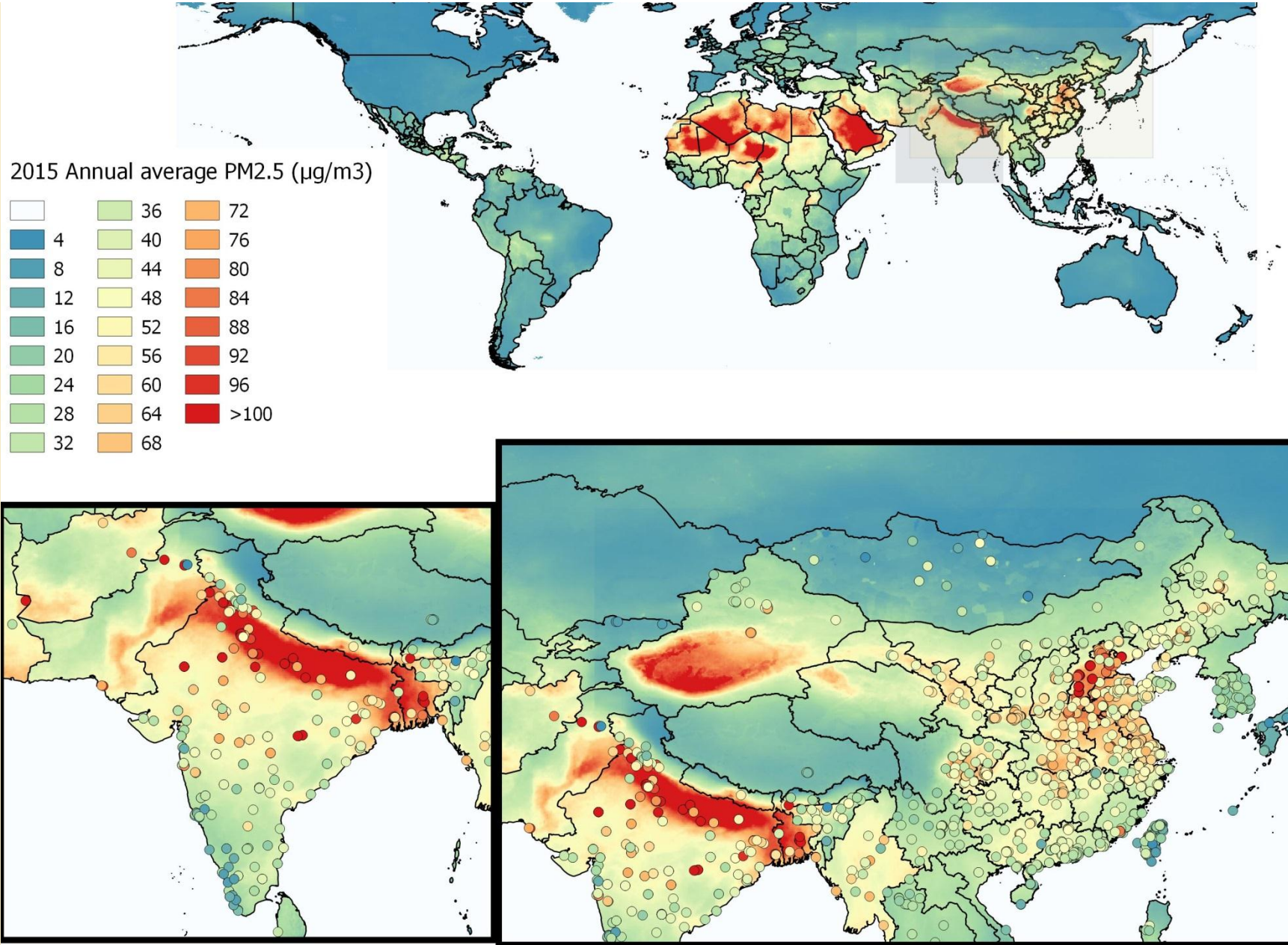
Good news: Longer lives worldwide

But, more people dying from diseases of aging



First Step: Estimating 2015 Global Average $PM_{2.5}$

Enhanced ground monitoring and other data leading to higher quality estimates



GBD 2015: Growing Number of Measurements in East and South Asia

	GBD2013		GBD2015	
Country	PM2.5	PM10	PM2.5	PM10
China	96	312	1035	
India	14	186	14 (+8)	357
Bangladesh	4	3	11	1
Pakistan	1	0	6	0
Nepal	0	1	0	1
Bhutan	0	1	0	5
Afghanistan	0	0	2	0

Second Step: Estimating Mortality Risk for the Global Burden of Ambient $PM_{2.5}$

- **Five Major Diseases related to PM2.5**
  - Ischemic heart disease (IHD)
  - Stroke
  - Chronic obstructive lung disease(COPD)
  - Lung cancer
  - Lower respiratory infection (Age 0 – 5)
- **Four of Five are Diseases of Aging…**

The Growing Number of Ambient Air Pollution Adult Mortality Studies - from Asia, Europe, North America - provide key links between PM and Premature Mortality

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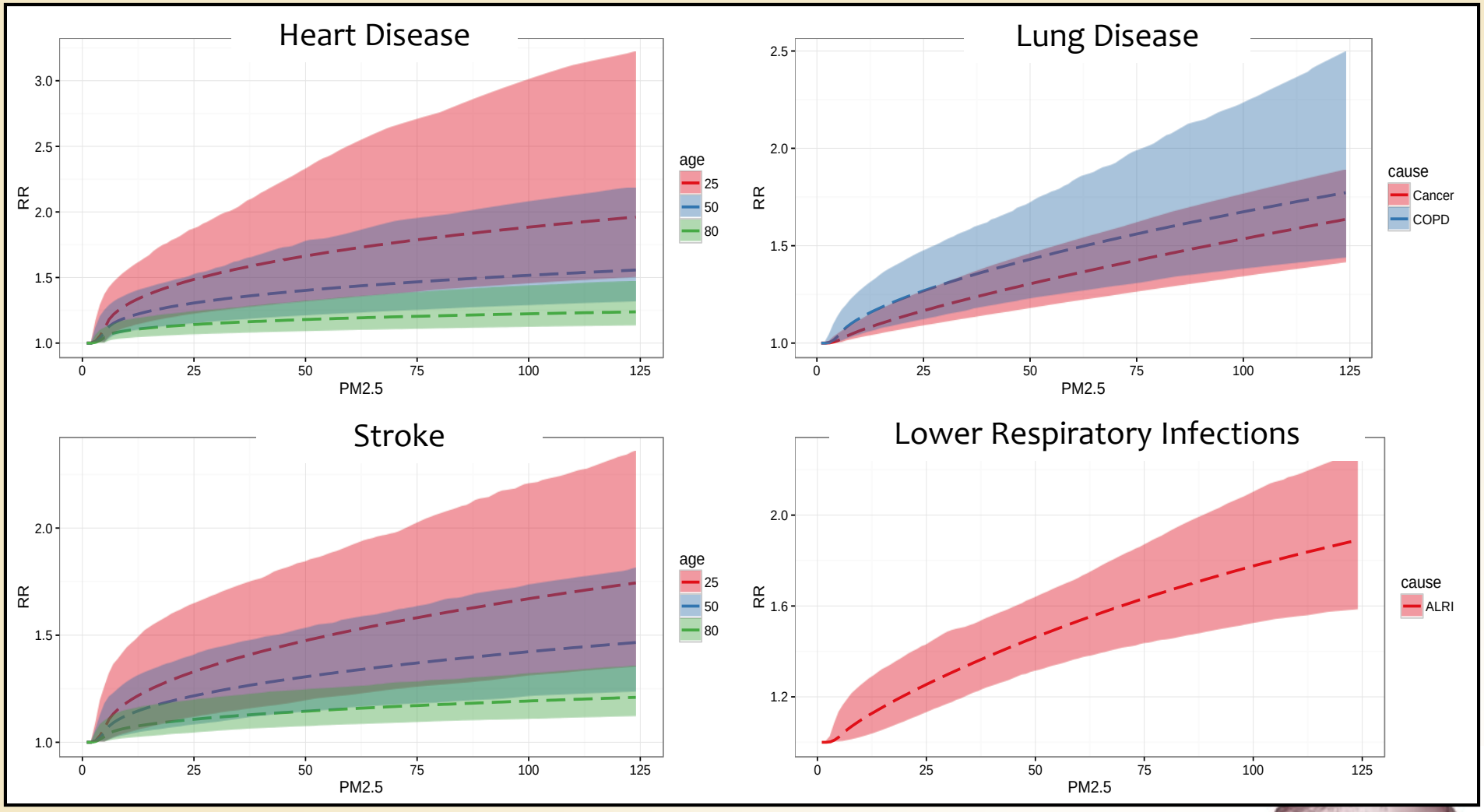
GBD 2015 Integrated Exposure Response Functions

Linking PM Exposure to Health



GBD Risk Factor Collaborators 2016; Cohen/Brauer et al. 2016 Submitted

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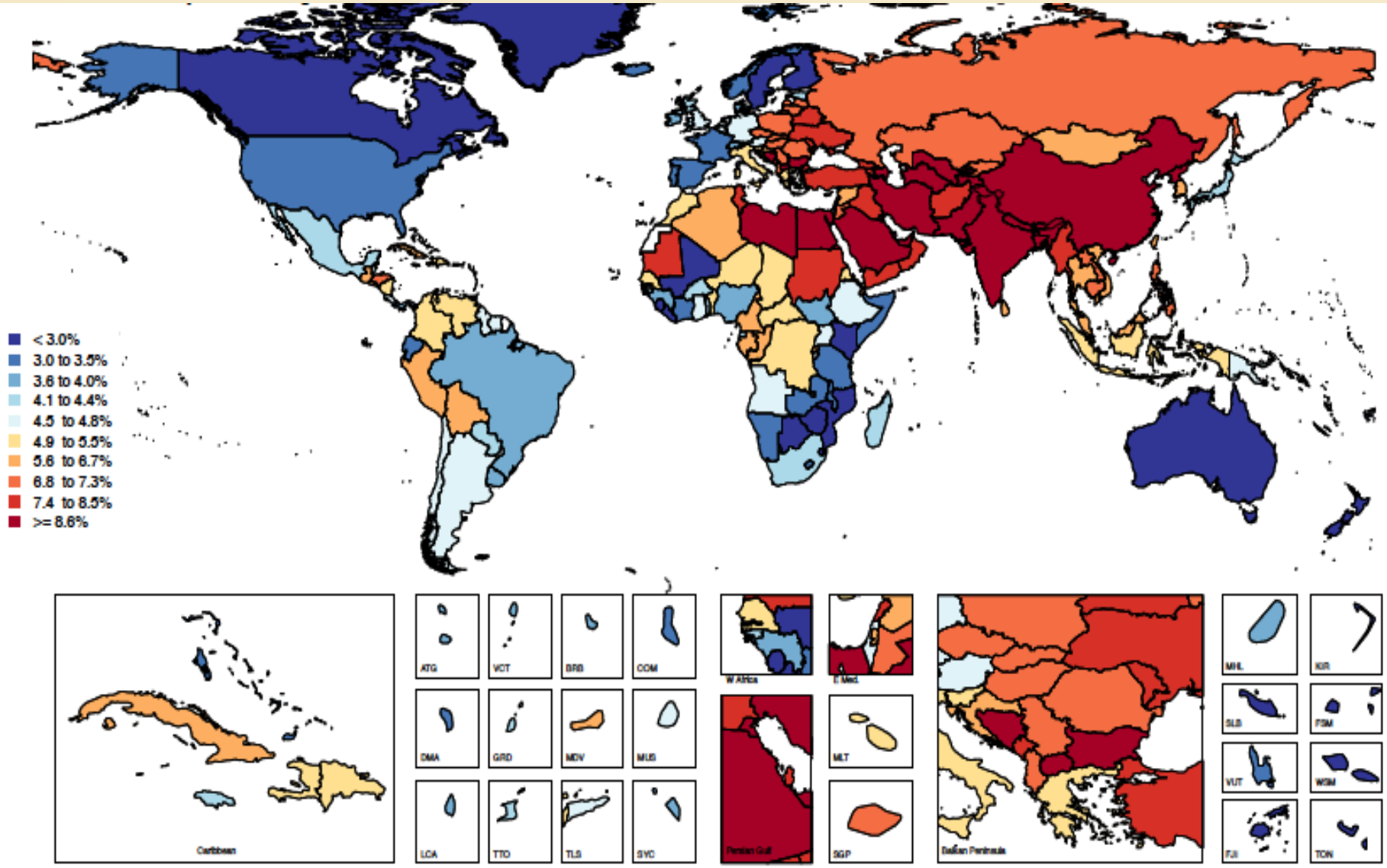
Percent of total deaths in 2015 attributable to ambient $PM_{2.5}$

India and China: Greater than 9% of all deaths



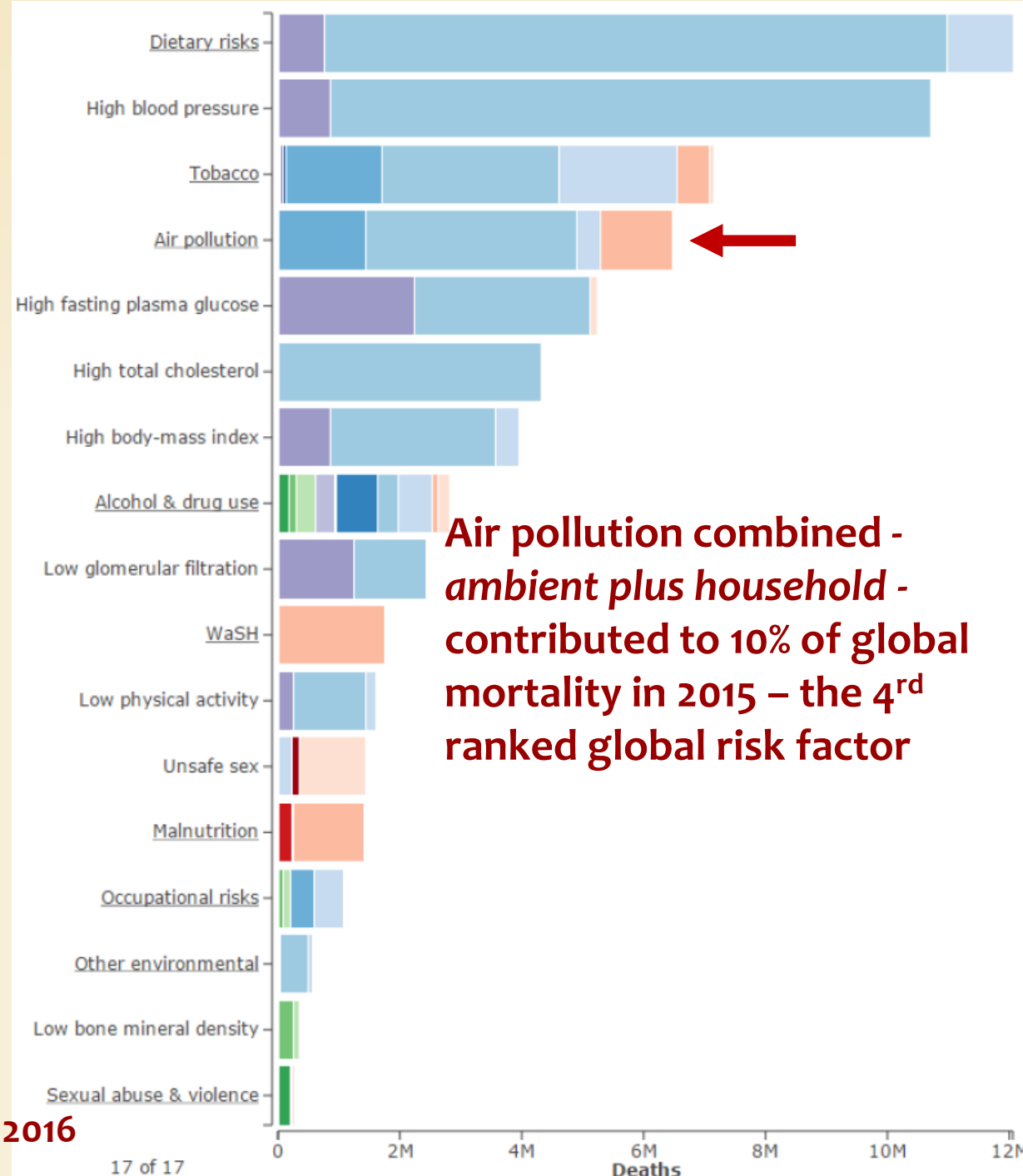
http://vizhub.healthdata.org/gbd-compare/

Third Step:
Comparing Air Pollution to All Other Risks

GBD 2015 Premature Deaths: Air Pollution among top-ranked *global* risk factors

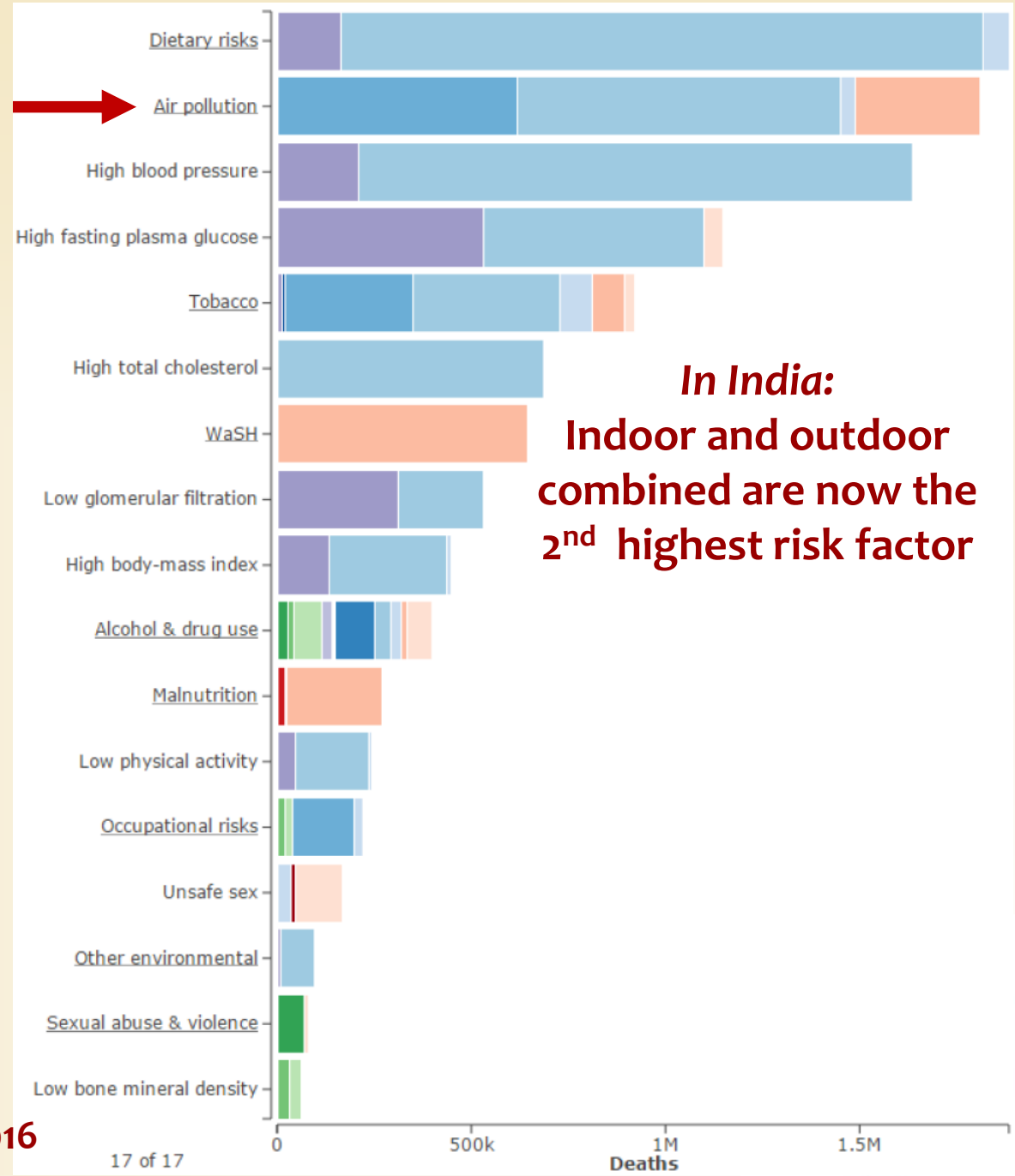
Outdoor PM contributed to 4.2 million premature deaths

GBD 2015 The Lancet 7 October 2016



Air pollution combined - *ambient plus household* - contributed to 10% of global mortality in 2015 – the 4rd ranked global risk factor

India GBD 2015: Premature Deaths attributable to combined risk factors



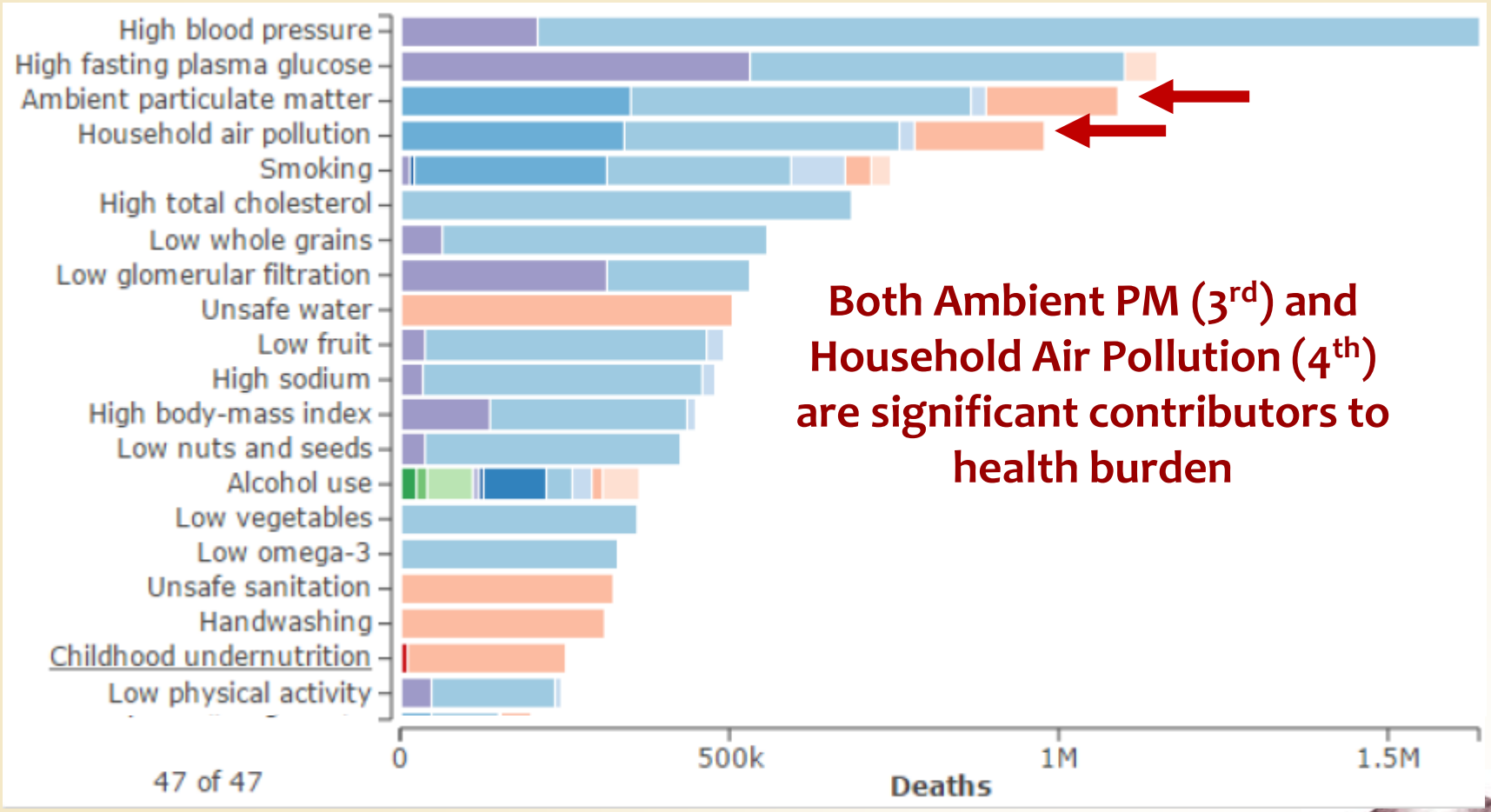
In India:

Indoor and outdoor combined are now the 2nd highest risk factor

GBD 2015 The Lancet 7 October 2016

India: Deaths attributable to all Risk Factors 2015

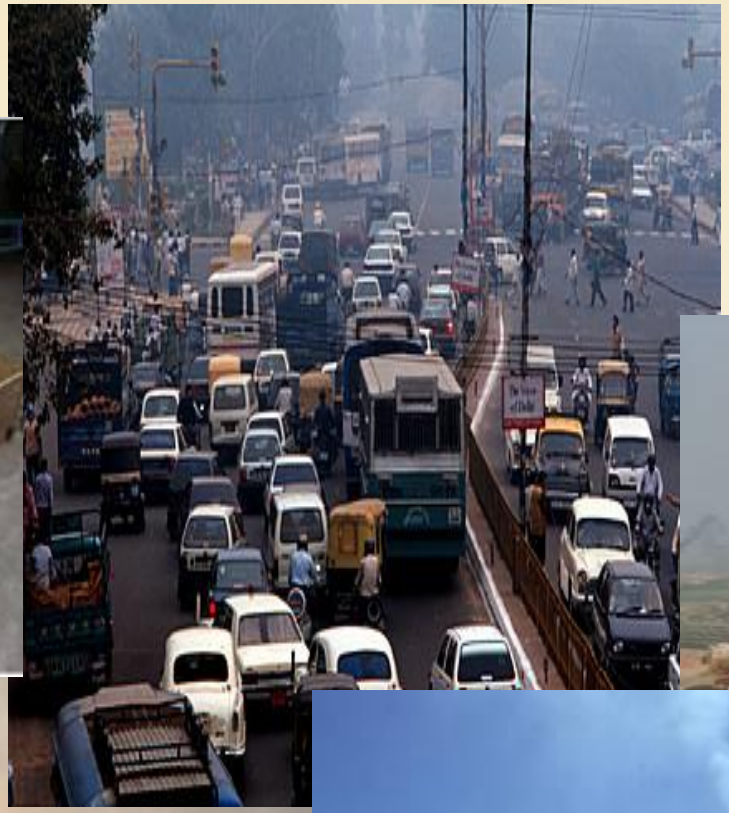
Ambient PM Ranks 3rd overall, contributing to 1.1 million premature deaths each year



GBD 2015 The Lancet 7 October 2016

A Fourth Step:
Understanding Health Burdens from Different Sources to Achieve Cleaner Air

Many Sources of PM in India



GBD MAPS: Understanding Source Specific Impacts

- Source-specific impacts best inform, drive climate and air pollution control measures
- GBD MAPS: ***G***lobal ***B***urden of ***D***isease from ***M***ajor ***A***ir ***P***ollution ***S***ources
- New HEI-IHME initiative to understand source-specific impacts (e.g. transport, biomass, coal)
  - ***China, India, Eastern Europe***, in a global context
  - Using GBD methods, data
  - At national, provincial levels
- In partnership with leading Chinese, Indian partners (Tsinghua, IIT-B, others)

Underway now; China results published August 2016;

India in Spring 2017

HEI

Trusted Science ● Cleaner Air ● Better Health

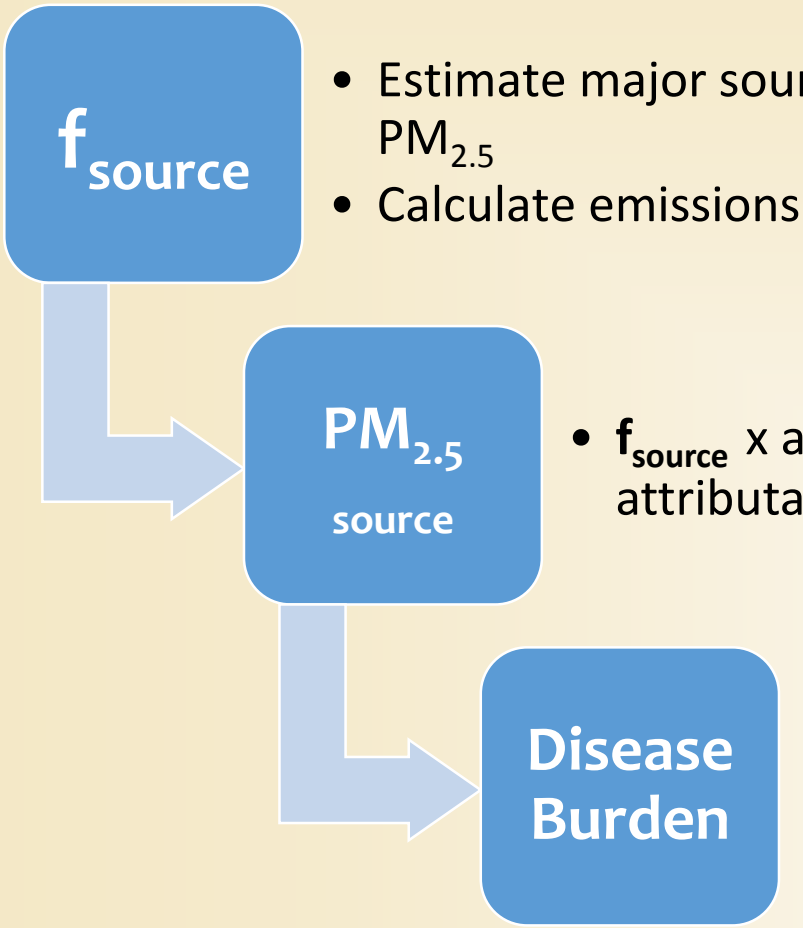
GBD MAPS International Steering Committee

Dan Greenbaum / Bob O'Keefe	Health Effects Institute
Terry Keating	US EPA
Hao Jiming	Tsinghua University
Yang Gonghuan	Peking Union Medical College
Christopher Murray	IHME
Majid Ezzati	Imperial College, London
K Srinath Reddy	Public Health Foundation of India, Delhi
Michal Krzyzanowski	Kings College, London
Greg Carmichael	WMO/U Iowa

GBD MAPS: All the Major Sources

- Transportation (on-road, non-road)
- Household Biomass
- Brick Kilns
- Coal:
  - Power, Industry, Domestic
- Non-coal Industrial
- Agriculture
- Open Burning

GBD-MAPS general methodology



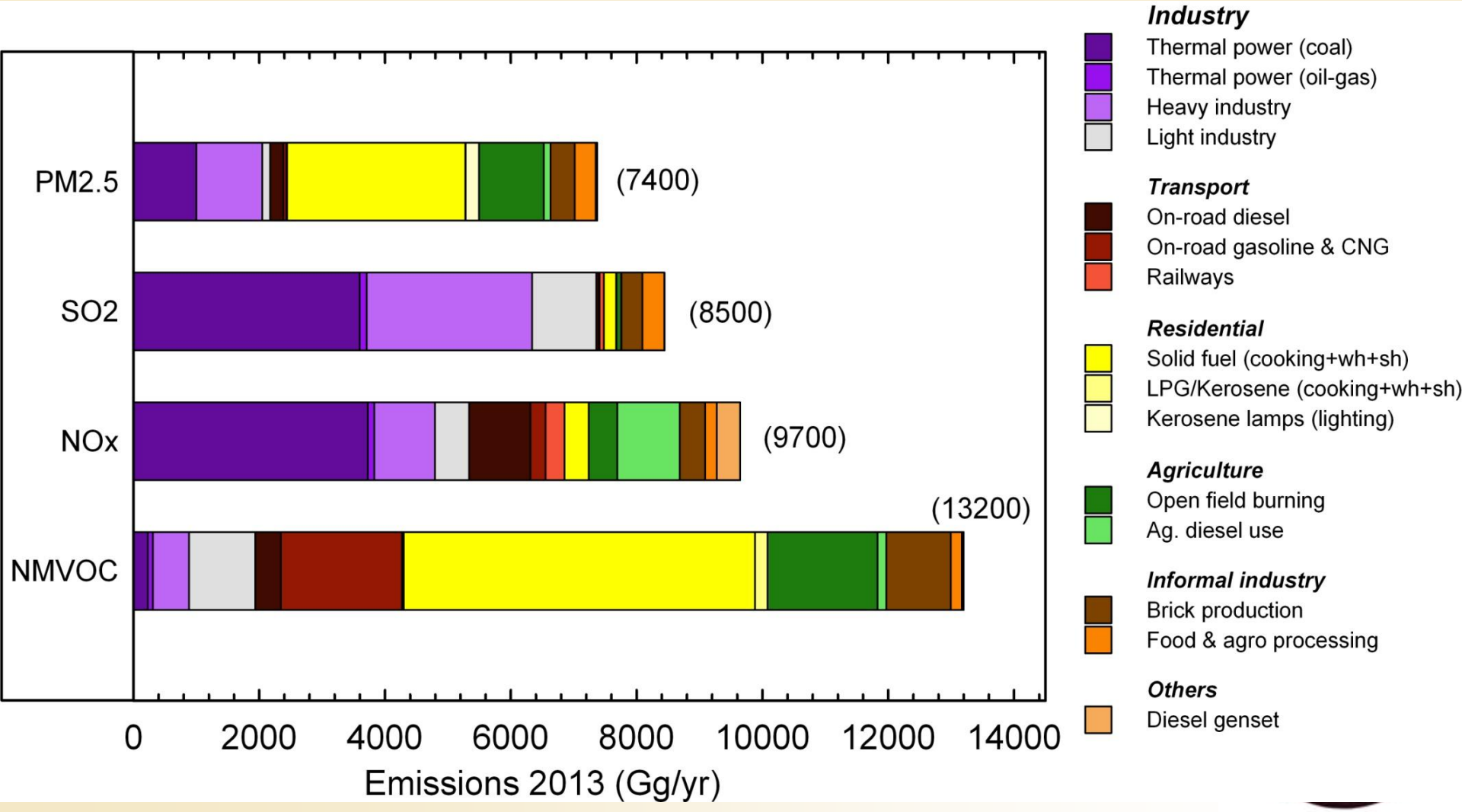
- Estimate major source contribution to ambient $PM_{2.5}$
- Calculate emissions from all major sources

- $\mathbf{f_{source}}$ x ambient $PM_{2.5}$ **=** ambient $PM_{2.5}$ attributable to each source

- Use integrated exposure response functions and cause-specific mortality estimates in combination with $\mathbf{PM_{2.5\ source}}$ **=** source contribution to disease burden

GBD MAPS:

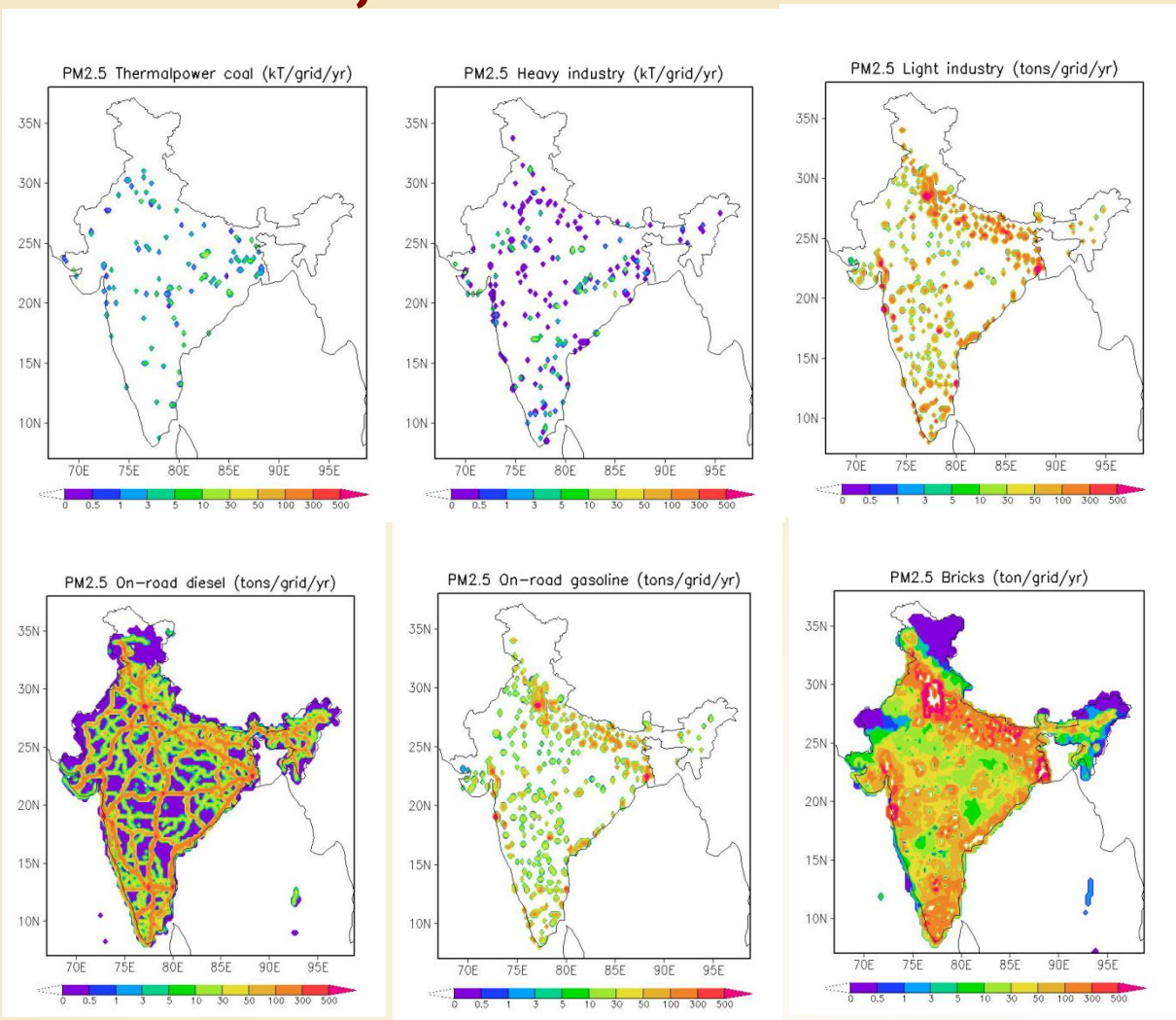
Estimate of India source primary emission contributions to ambient $PM_{2.5}$ using latest available information on current emissions (2013)



Spatial Extent of Source Emission Estimates

Power, Industry

Transport, Brick Kilns



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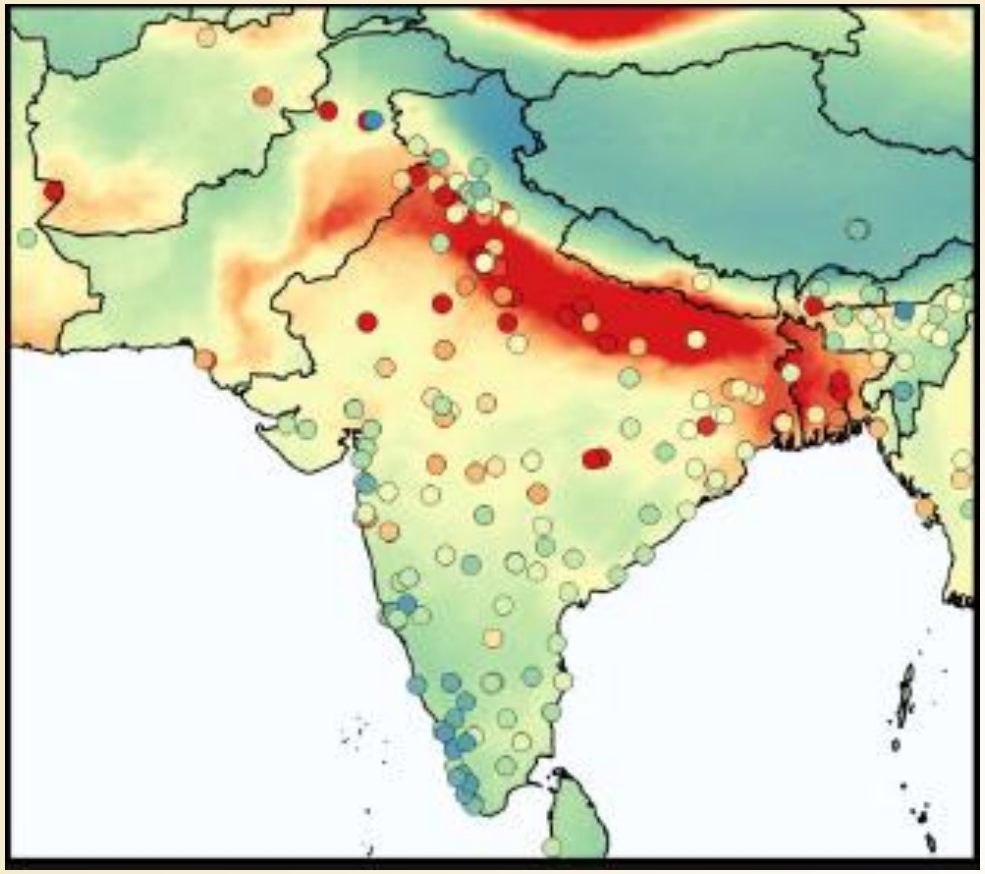
2015 Annual Average $PM_{2.5}$

Emission factors will then be applied to estimate Indian source-specific population exposure



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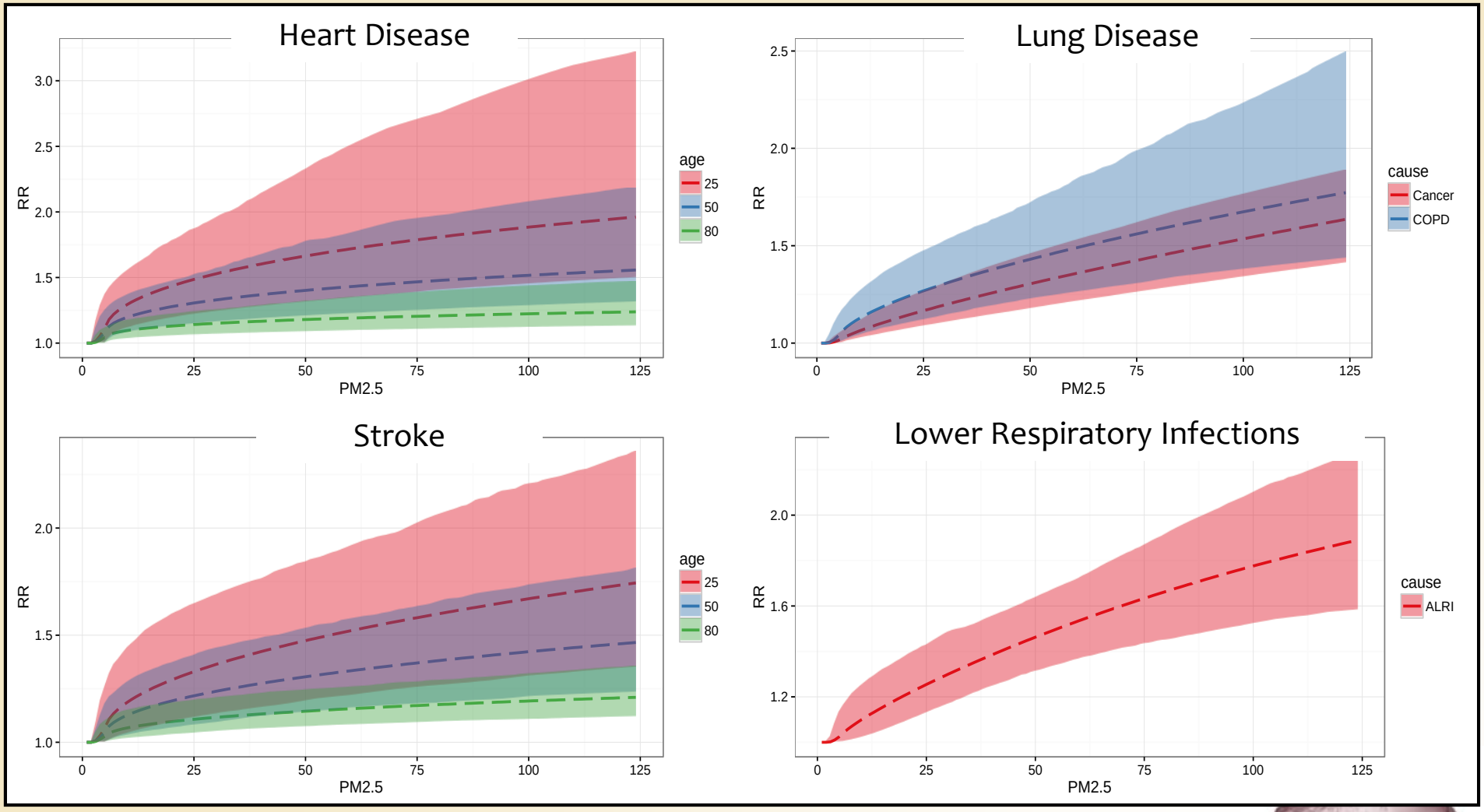

GBD Risk Factor Collaborators 2016; Cohen/Brauer et al. 2016 Submitted

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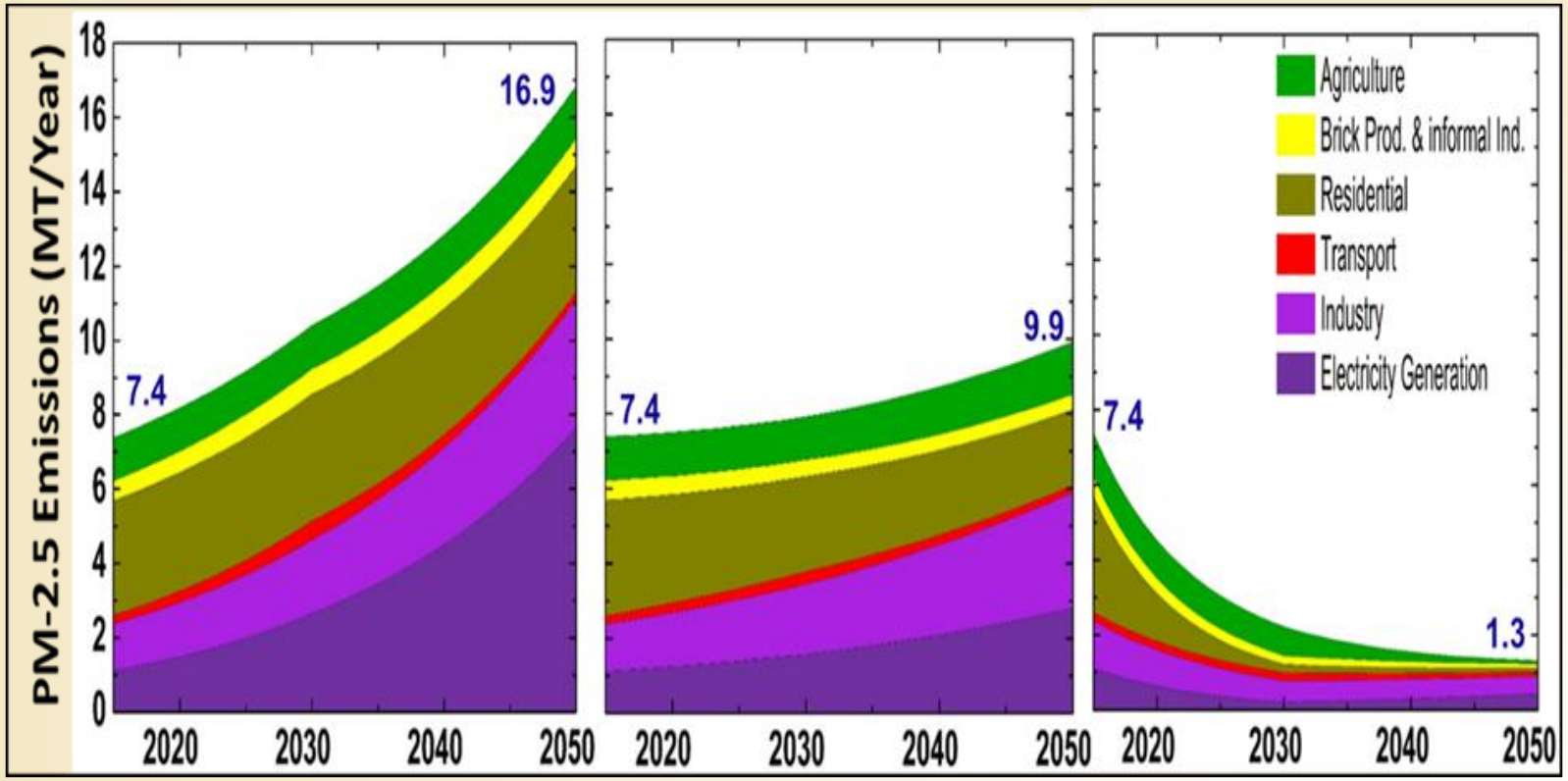
Looking Forward:

GBD MAPS will project Business as Usual and Modest and Advance Control scenarios for all sources through 2050



Peer-Reviewed Final GBD MAPS India results in April 2017

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The Special Case of Traffic Sources

Traffic Related Air Pollution & Health: An Expert HEI Review 2010

Summarized & synthesized over 700 studies on health effects of traffic

- *However, not **all** of equal quality*

Found :

- ***Highest exposures 300-500 meters from major roads***
- *Growing evidence of effects, especially asthma exacerbation in children*

New:

- ***HEI Traffic Exposure, Tunnel Studies underway***
- ***Updated traffic expert review to get underway in 2017 (10 more years of data)***
- ***Initiating new Studies of traffic and health***

The New York Times

January 13, 2010

Report Links Vehicle Exhaust to Health Problems

A relationship was found between pollution from vehicles and impaired lung function and accelerated hardening of the arteries.

By MATTHEW L. WALD

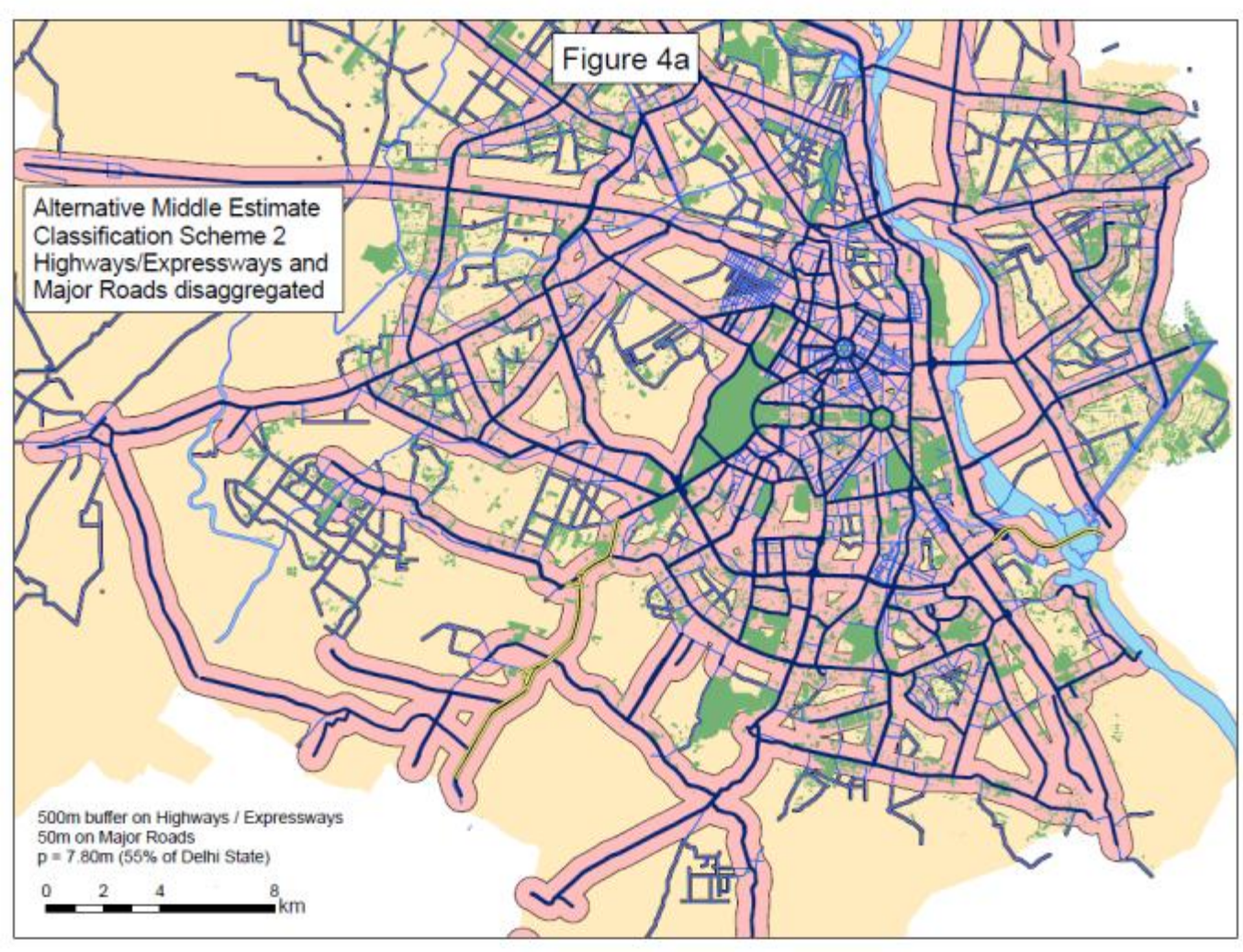
Exhaust from cars and trucks exacerbates asthma in children and may cause new cases as well as other respiratory illnesses and heart problems resulting in deaths, an independent institute that focuses on vehicle-related air pollution has concluded.

The report, to be issued on Wednesday by the nonprofit Health Effects Institute, analyzed 700 peer-reviewed studies conducted around the world on varying aspects of motor vehicle emissions and health. It found "evidence of a causal relationship," but not proof of one, between pollution from vehicles and impaired lung function and accelerated hardening of the arteries.

It said there was "strong evidence" that exposure to traffic helped cause variations in heart rate and other heart ailments that result in deaths. But among the many studies that evaluated death from heart problems, some did not separate stress and noise from air pollution as a cause, it said.

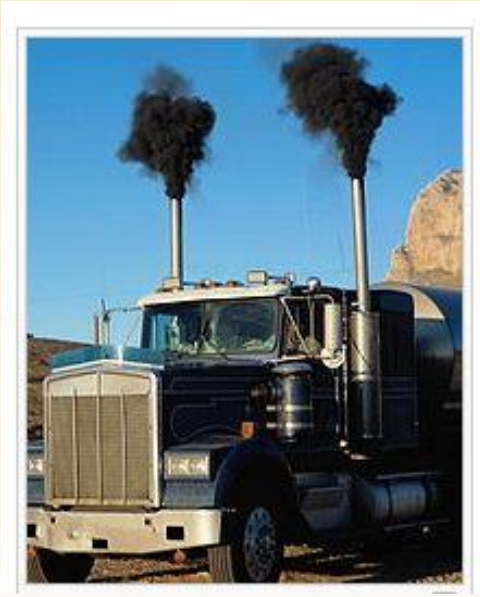
The Traffic Impact Area in Delhi:

HEI Analysis: ***55% of the Population*** *within 500 meters of a Freeway; 50 meters of a Major Road*



A Key Challenge: Old Diesel

- Primary health concern: *effects on the heart from exposure to **Particulate Matter** (PM) from older diesel*
  - Significant effects on mortality, life expectancy
  - Strong evidence of respiratory effects: *reduced lung function, respiratory irritation, asthma exacerbation*
- *IARC (WHO) Review of diesel carcinogenicity (2012)*
  - *Diesel a "Known Human Carcinogen"*
  - *Based on Two Major Occupational Studies (reviewed in HEI 2015 Special Report):*
    - *US Diesel Exposed Miners Study (DEMS)*
    - *US Truckers Study*
- ***Exposure to older diesel pervasive in much of the world***



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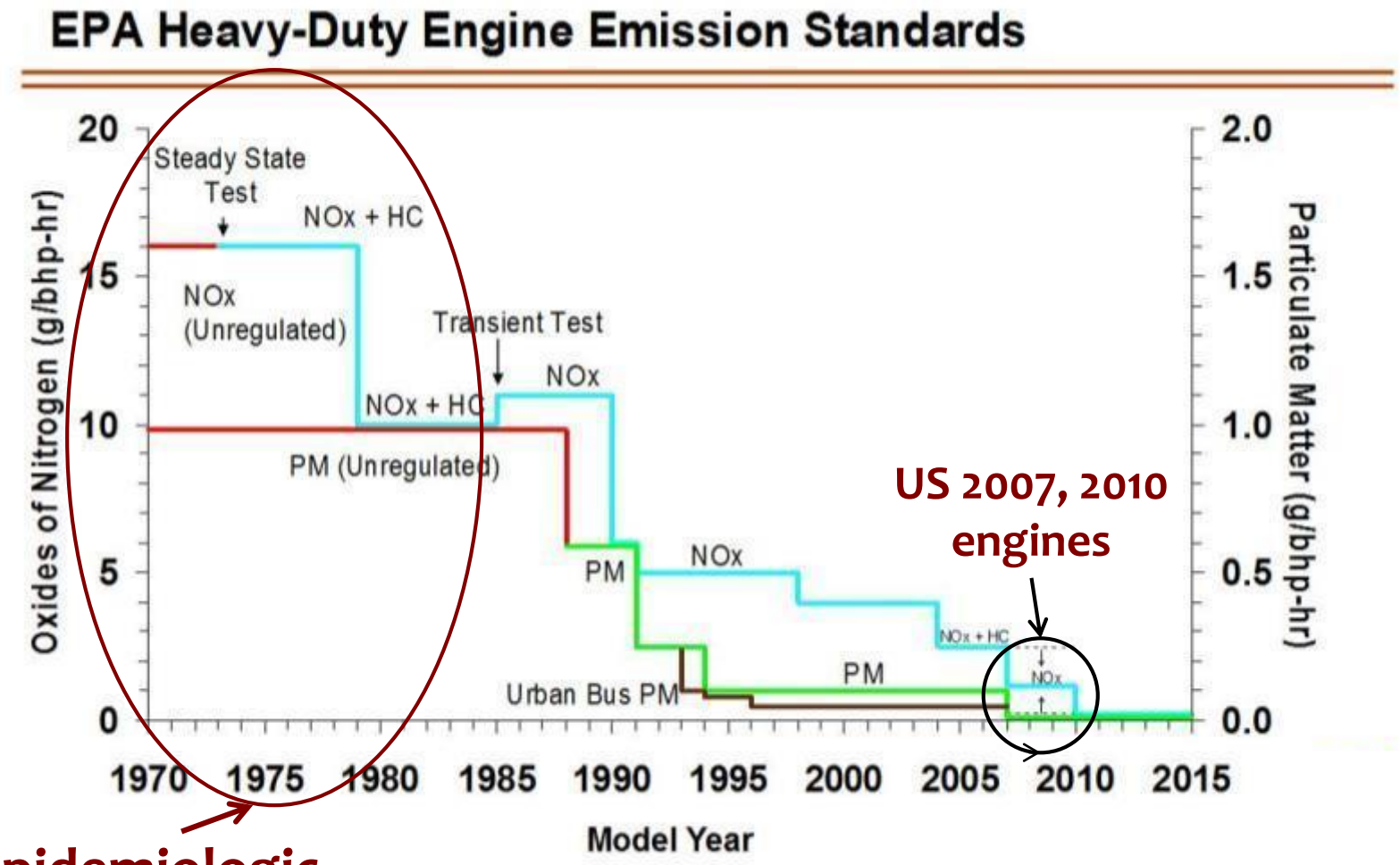
The Policy Response: New Technology Diesel

US 2007/2010 Rules; EURO 6/VI (2015); China 6/VI (2017); B.S. 6/VI (2020)



And Now:

Evidence that Traffic Actions Can Improve Health!

Los Angeles Then and Now

Source: New York Times

HEI

A New HEI "Accountability" Study: AQ and Health in LA Gauderman et al March 5, 2015

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 MARCH 5, 2015 VOL. 372 NO. 10

Association of Improved Air Quality with Lung Development in Children

W. James Gauderman, Ph.D., Robert Urman, M.S., Edward Avol, M.S., Edward Rappaport, M.S., Roger Chang, Ph.D., Fred Lurmann, M

With major vehicle fuel and emissions rules, Air Quality Improved

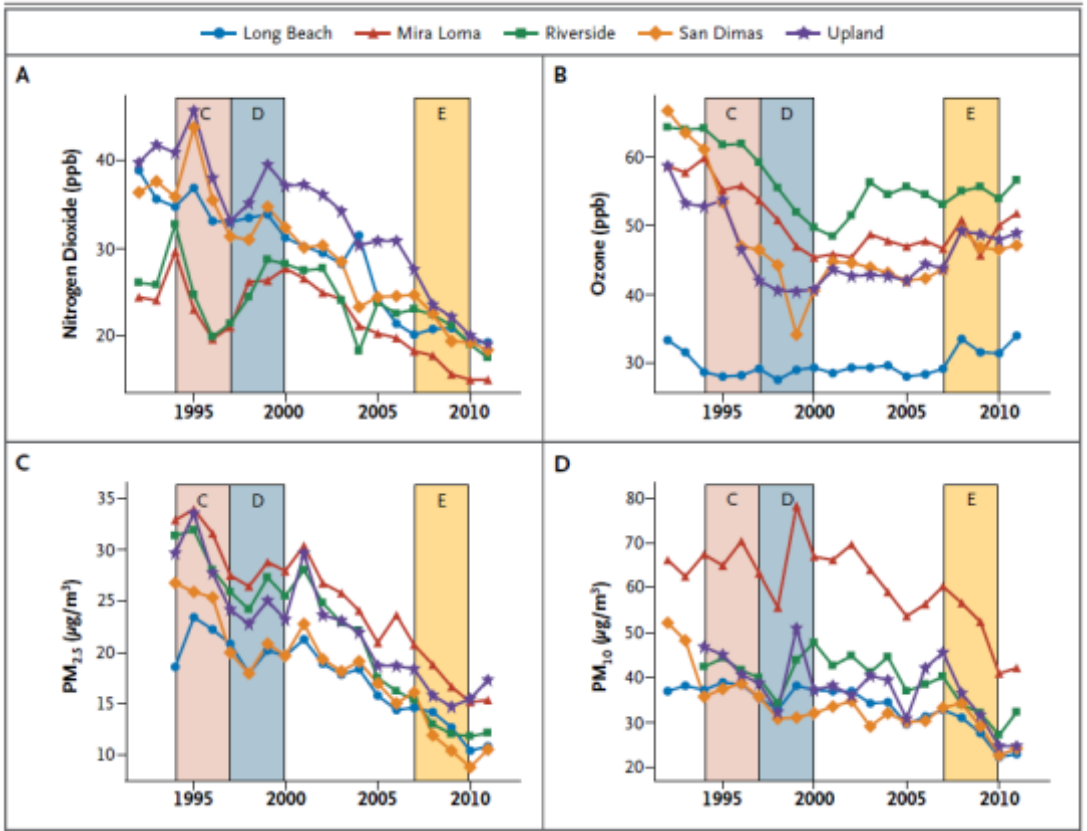


Figure 1. Levels of Four Air Pollutants from 1994 to 2011 in Five Southern California Communities.
Colored bands represent the relevant 4-year averaging period for the analysis of lung-function growth in each of the three cohorts, C, D, and E. $PM_{2.5}$ denotes particulate matter with an aerodynamic diameter of less than 2.5 μm, and PM_{10} particulate matter with an aerodynamic diameter of less than 10 μm.

Cleaner Air and Improved Lung Health

- Tracked growth in Lung Function in 3 "cohorts" (2,100 children total) in Southern California 1994 – 2011
- Saw notable improvement in lung function in the most recent cohort (who grew up 2007 – 2011 in cleaner air)

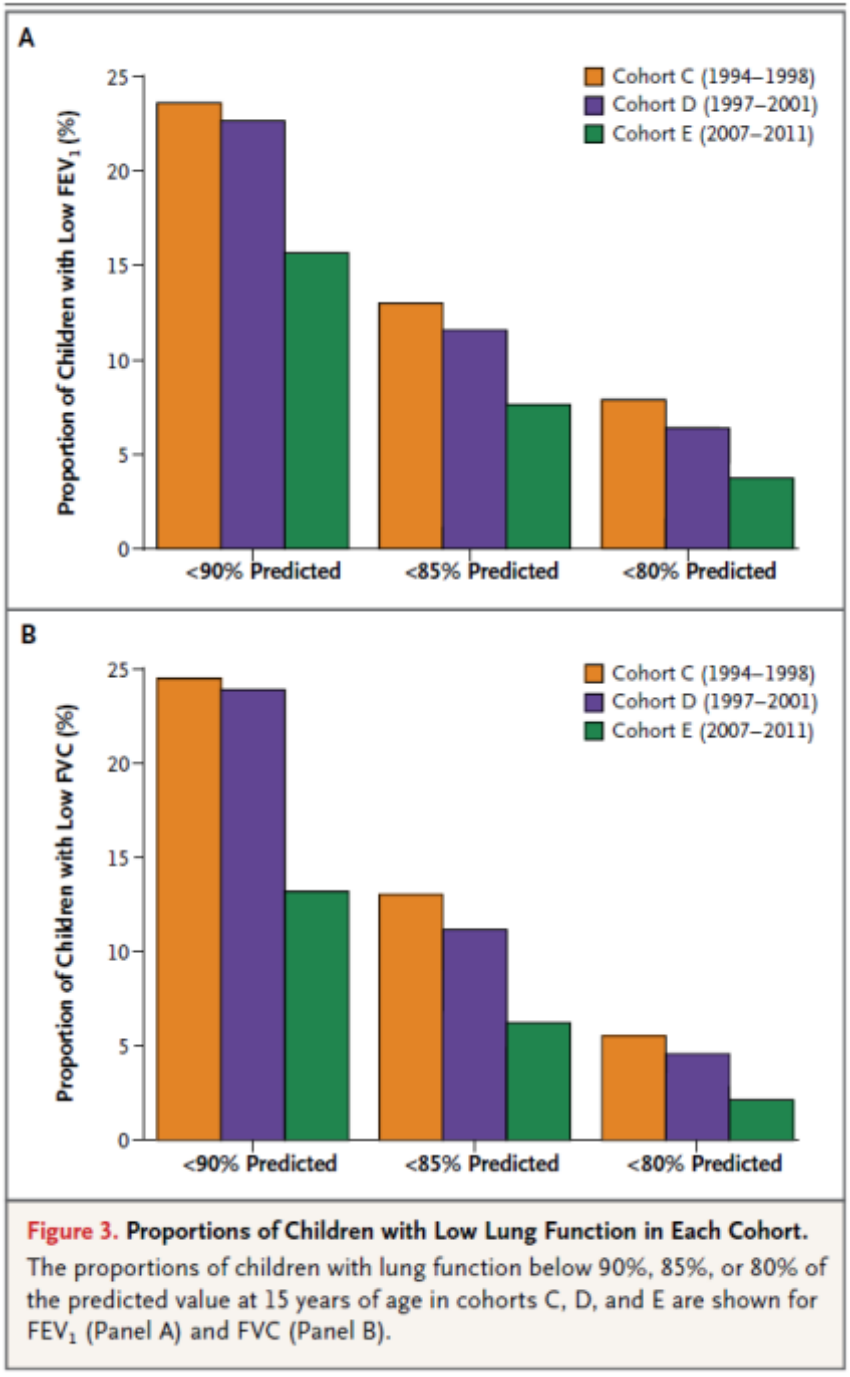


Figure 3. Proportions of Children with Low Lung Function in Each Cohort.
The proportions of children with lung function below 90%, 85%, or 80% of the predicted value at 15 years of age in cohorts C, D, and E are shown for FEV_1 (Panel A) and FVC (Panel B).

Concluding Thoughts

- We know much more today about the Health Effects of Air Pollution in Asia
  - Growing science base
  - New Short and Long Term Studies
- GBD is increasing understanding of the population health burdens
  - ***GBD 2015*** includes new approaches to exposure and exposure-response
- Actions beginning in India:
  - AQI, BS VI Leapfrog, thermal power plants standards
- Source-specific impacts are likely to best inform and drive future control measures
  - GBD MAPS Report for India in Spring 2017
  - New Traffic Review and Studies

Thank You!

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